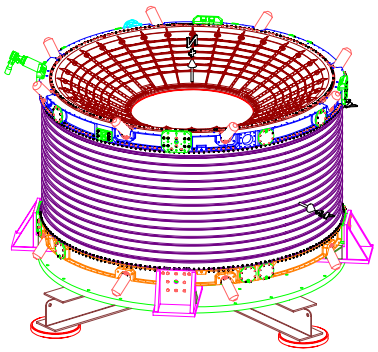
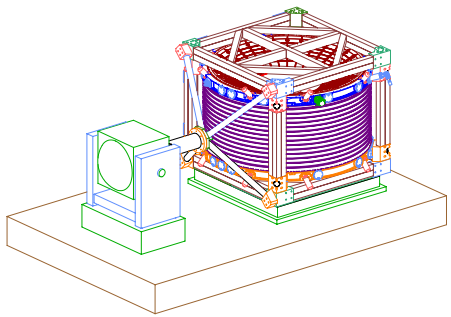
Alpha Magnetic Spectrometer (AMS) - 02

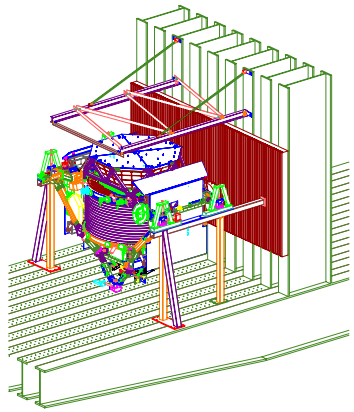
Critical Design Review

Structural Testing &

Cyromagnet System Testing Flow







Phil Mott

May 13-16, 2003

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Non-Linear Cryomagnet Support Straps Verification Testing

- Cryomagnet Support System Static Testing (England & US)
  - All strap components will have multiple tests to failure (completed)
  - All strap components will have multiple fatigue tests (completed)
  - 2 complete strap assemblies tested for fatigue & failure
    - Static test to 1.0 x limit load to characterize the strap (completed)
    - Fatigue tested – includes transportation, launch, on-orbit, landing (completed)
    - Another static test to 1.0 x limit load to compare to pre-fatigue static test (completed)
    - Straps will then be dynamically tested (see dynamic test section) (completed)
    - Following all previous testing, straps will be static tested to failure
      - Warm test at JSC STL – J13
      - Cold test at CTG in England
  - Each STA & Flight strap will be tested to 1.2 x limit load

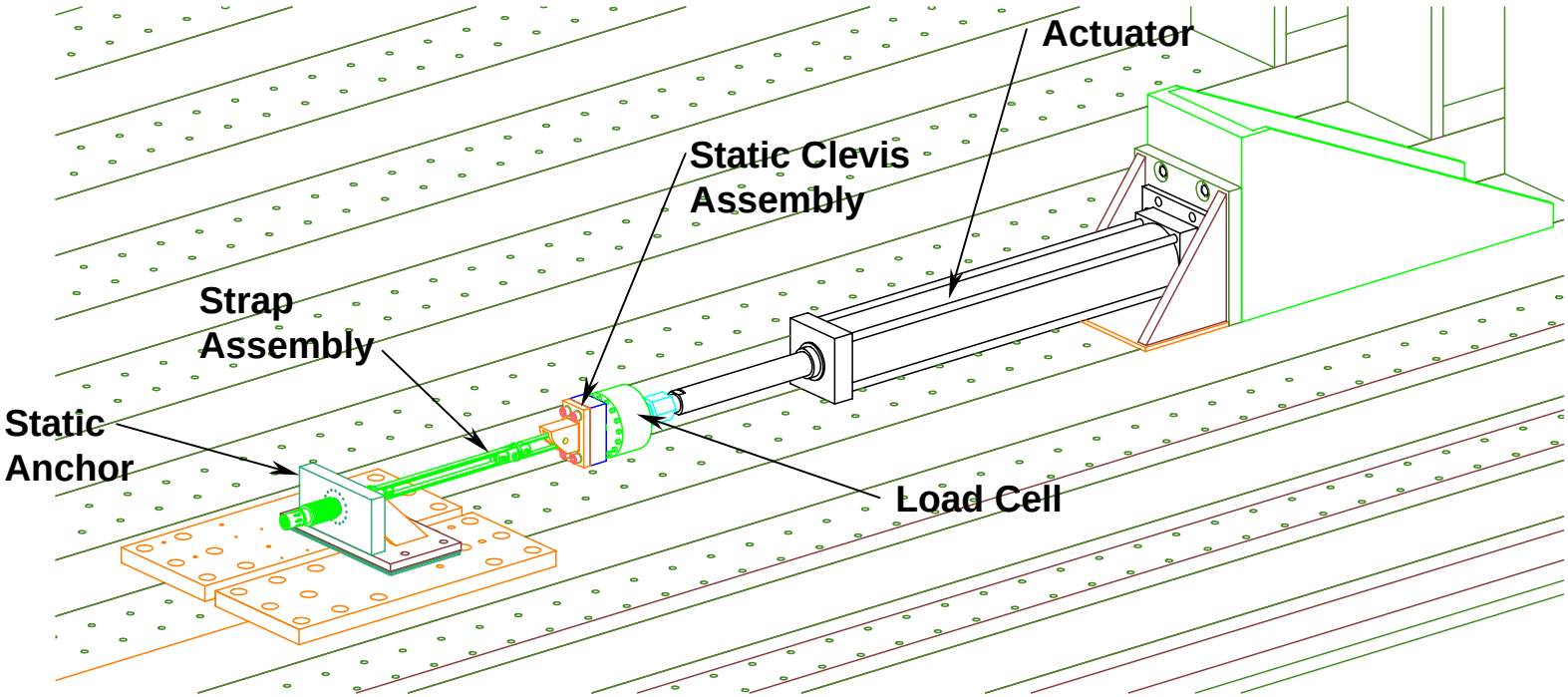
Cryomagnet Static Verification Testing

- Flight Cryomagnet Static Testing (England)
  - The Flight Cryomagnet will be tested to 1.1 x limit load due to magnetic forces
  - Each coil is tested to at least full current.
    - Strain gages are attached to 1 dipole coil and 1 racetrack coil for FEM correlation.

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Component Static Verification Testing

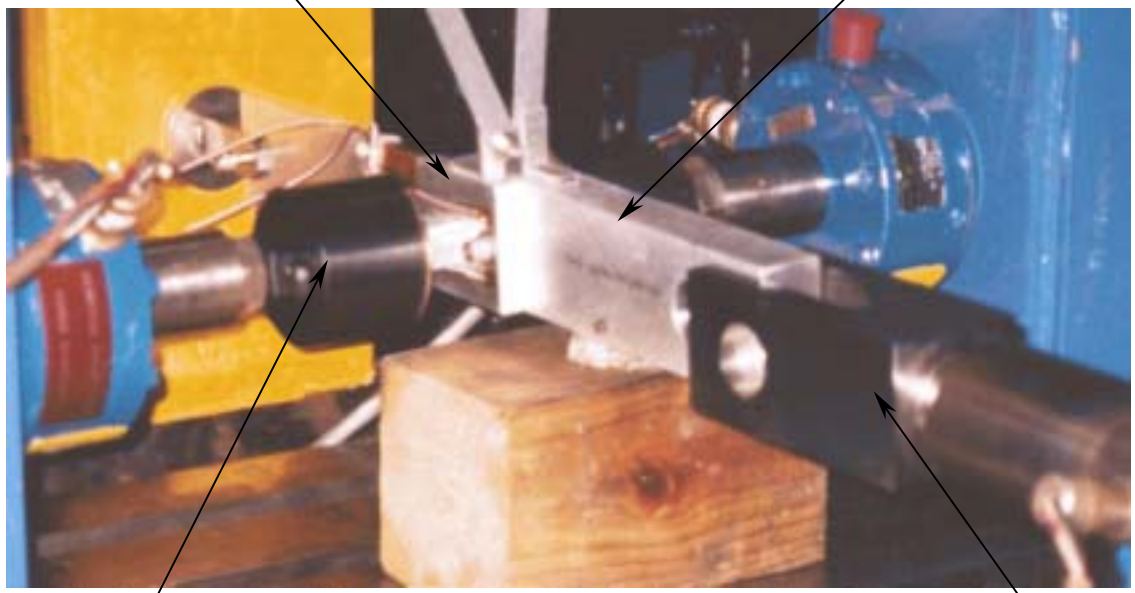
- **Component Level Static Tests**
  - **Strap Static Test (JSC STL – J13)**
    - **Test to 1.2 * Maximum Flight Load & check for yielding**
    - **Repeat Test to Failure**



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Component Static Verification Testing

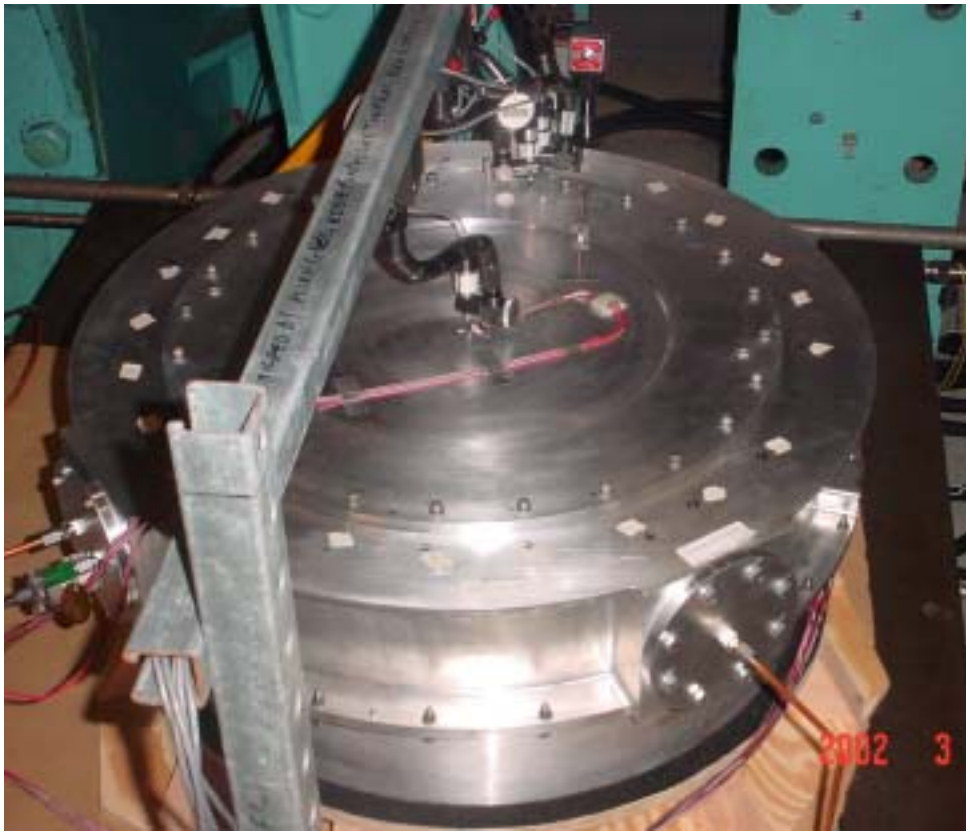
- **Component Level Static Tests (cont.)**
  - **VC Joint Stiffness Static Test (JSC STL – J13)**
    - **With and without liquid shim in joint clearance holes**
    - **Test each configuration to failure**
    - **Measure stiffness of each bolted joint for FEM correlation**

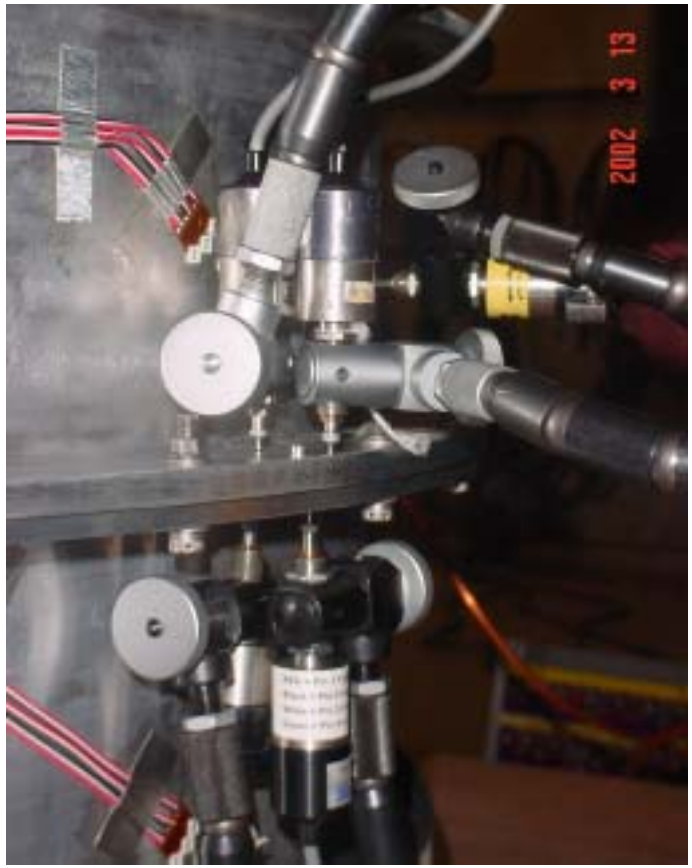


Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Component Static Verification Testing

- **Component Level Static Tests (cont.)**
  - **O-Ring Test Fixture Static Test (JSC STL – J13)**
    - **Positive Pressure (0.8 atm gauge)**
    - **Help correlate FEM**





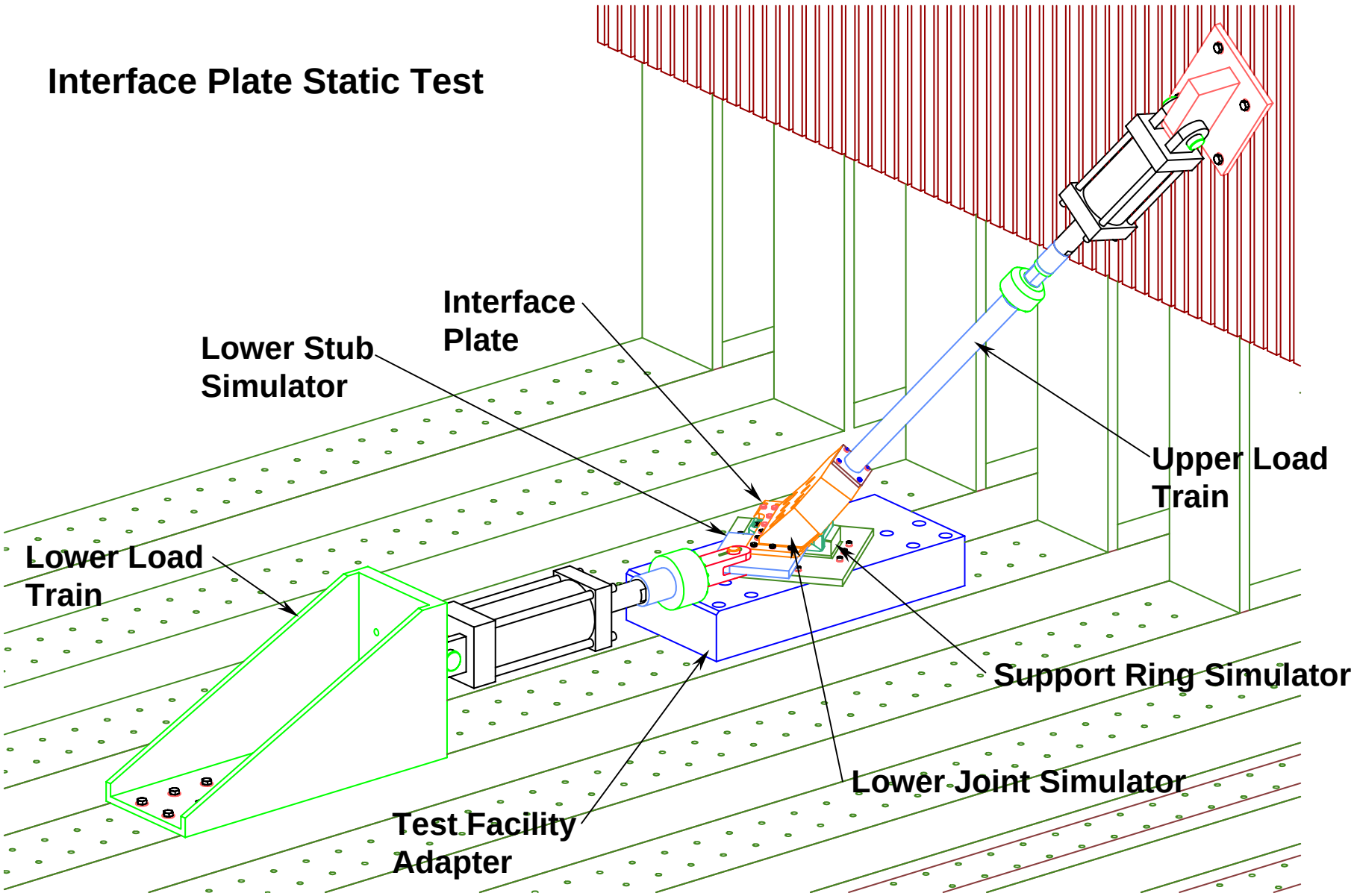
Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Component Static Verification Testing

- Component Level Static Tests (cont.)
  - Interface Plate Static Test (JSC STL – J13)
    - Lower USS-02 Joint to VC Interface Plate (low margin and analysis uncertainty)
      - Flight Interface Plate with Lower Joint Simulator
      - Test to 1.1 x limit and check for yielding
      - Repeat test to failure
  - Lower Joint Static Test (JSC STL – J13)
    - Lower USS-02 Joint (low margin)
      - Flight Lower Joint
      - Test to 1.1 x limit and check for yielding
      - Repeat test to failure

Component Static Verification Testing

Interface Plate Static Test



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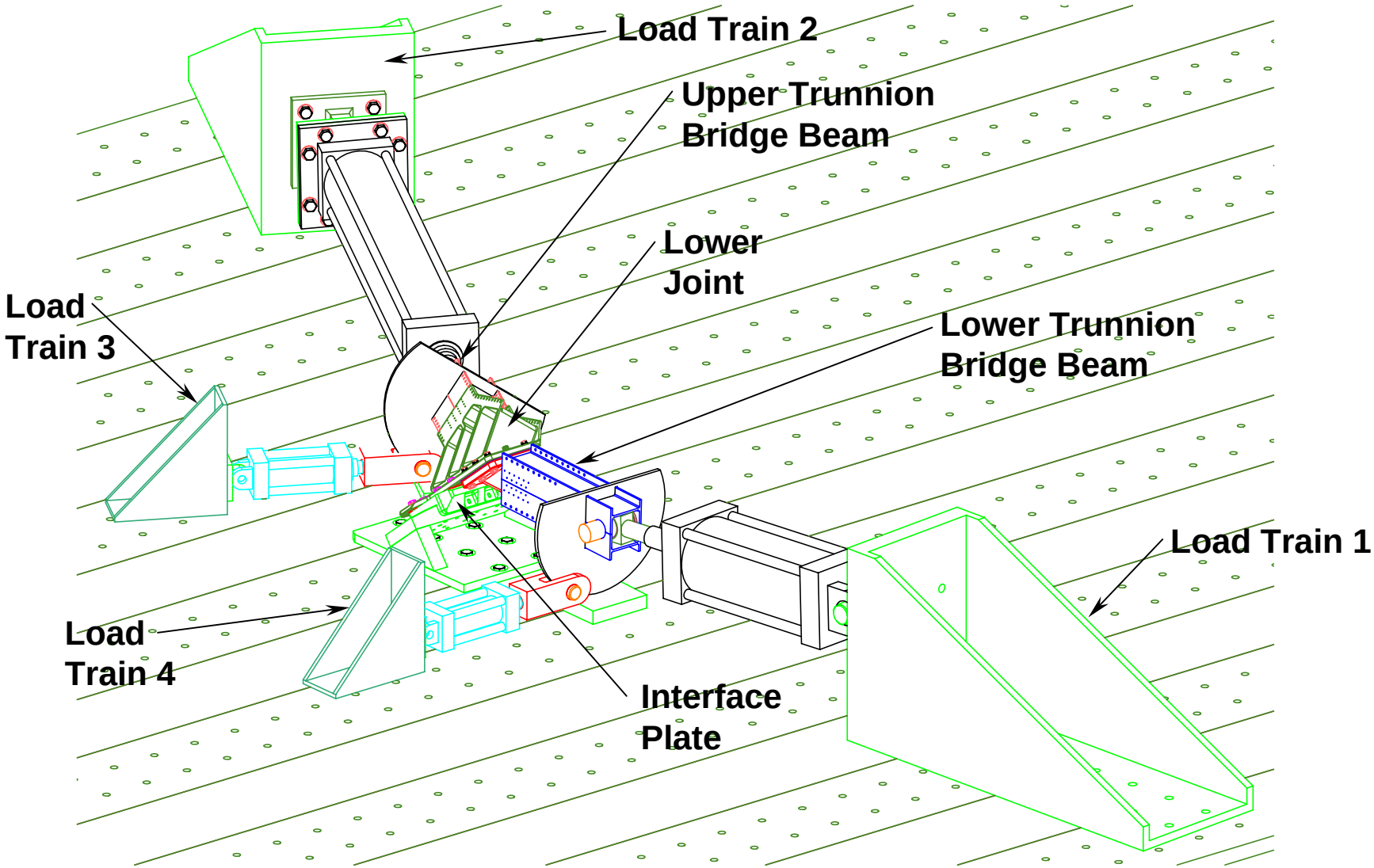
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Component Static Verification Testing

Lower Joint Static Test



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Component Static Verification Testing

- **PAS Static Test (LM3 – Completed February 2003)**
  - **ISS Configuration**
  - **Static tested to 1.5 x limit load to ensure that it will meet the required stiffness and deflection requirements**

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

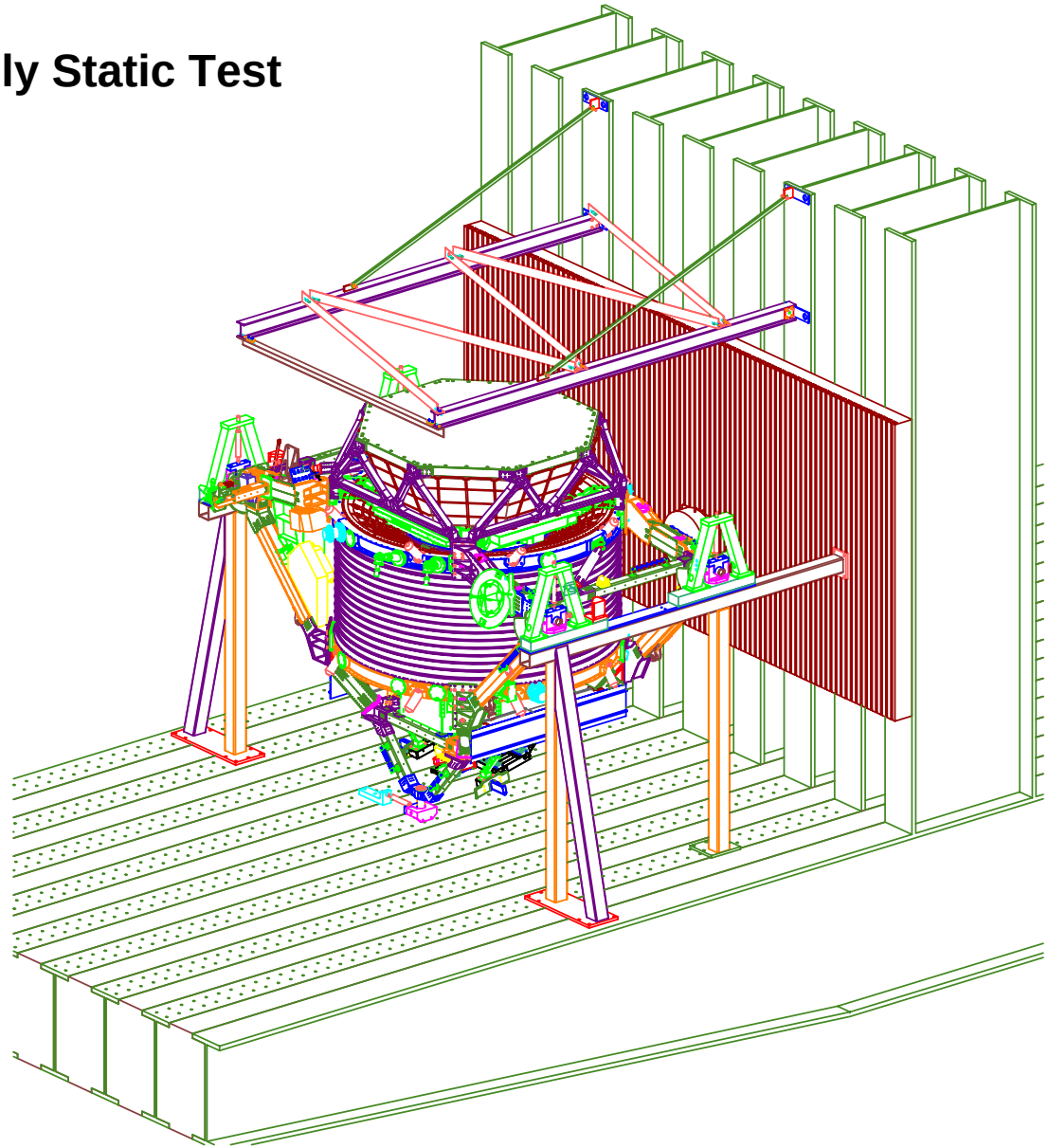
Static Verification Testing

- **Full Assembly Static Test (JSC STL – J13)**
  - **Orbiter Configuration simulated with modified test stands from AMS-01 on STS-91**
  - **Test to 1.1 x limit load**
  - **Will include enough instrumentation to correlate FEM to 1.4 x limit load**

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Static Verification Testing

Full Assembly Static Test



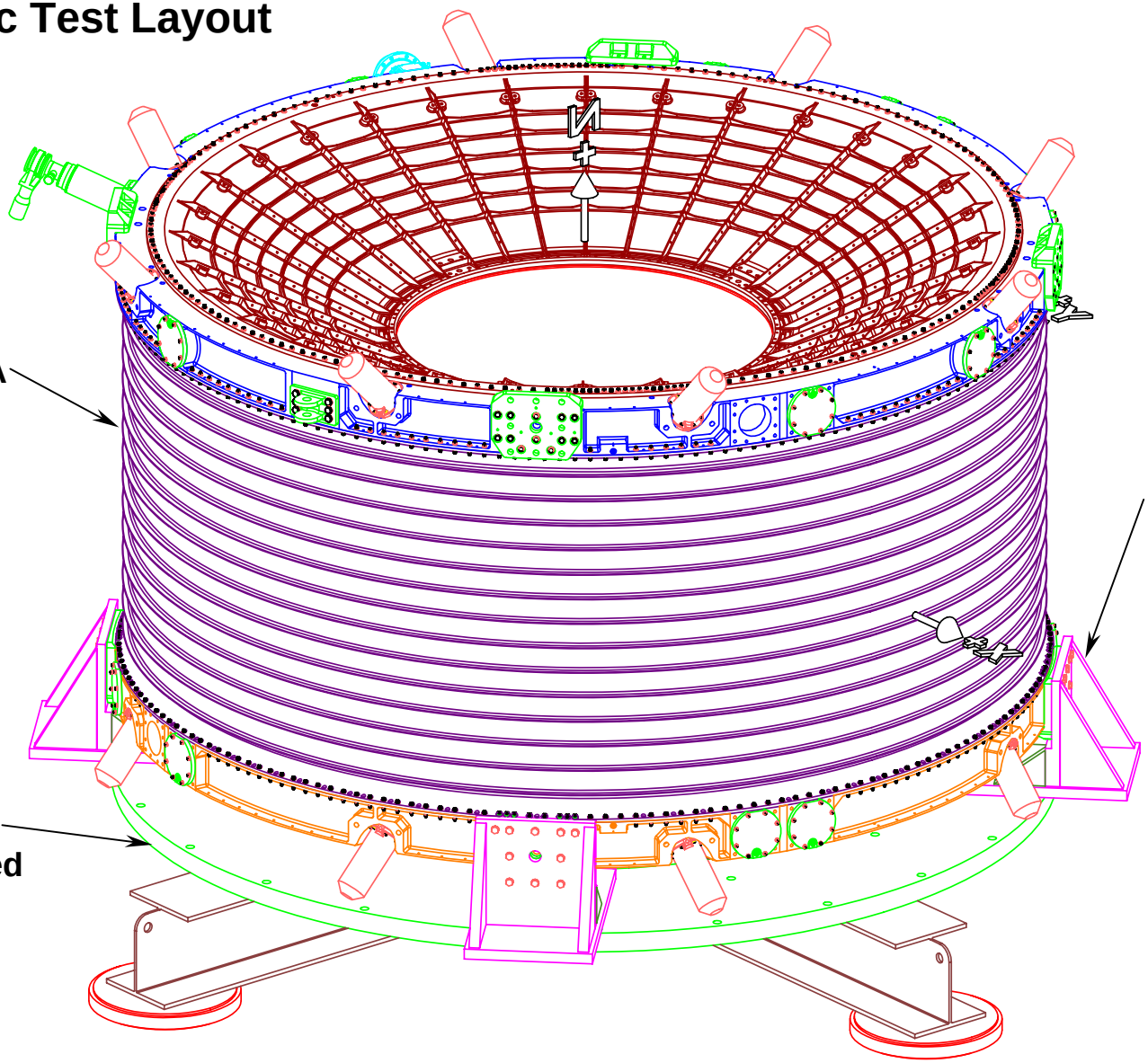
Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Frequency & Strength Verification Testing

- **Acoustic Tests**
  - **Cryomagnet System (ESTEC – The Netherlands)**
    - **Cryomagnet Structural Test Article (STA) [STA VC, STA SFHe Tank, Cold Mass Replica] will be tested to flight acoustic levels to determine if there is any o-ring seal leakage**
    - **Test must be performed with cryosystem at room temperature and vacuum in order to measure leaks in the o-ring seals**
    - **Strap preload increased to simulate thermal load of Cold Mass Replica**

Frequency & Strength Verification Testing

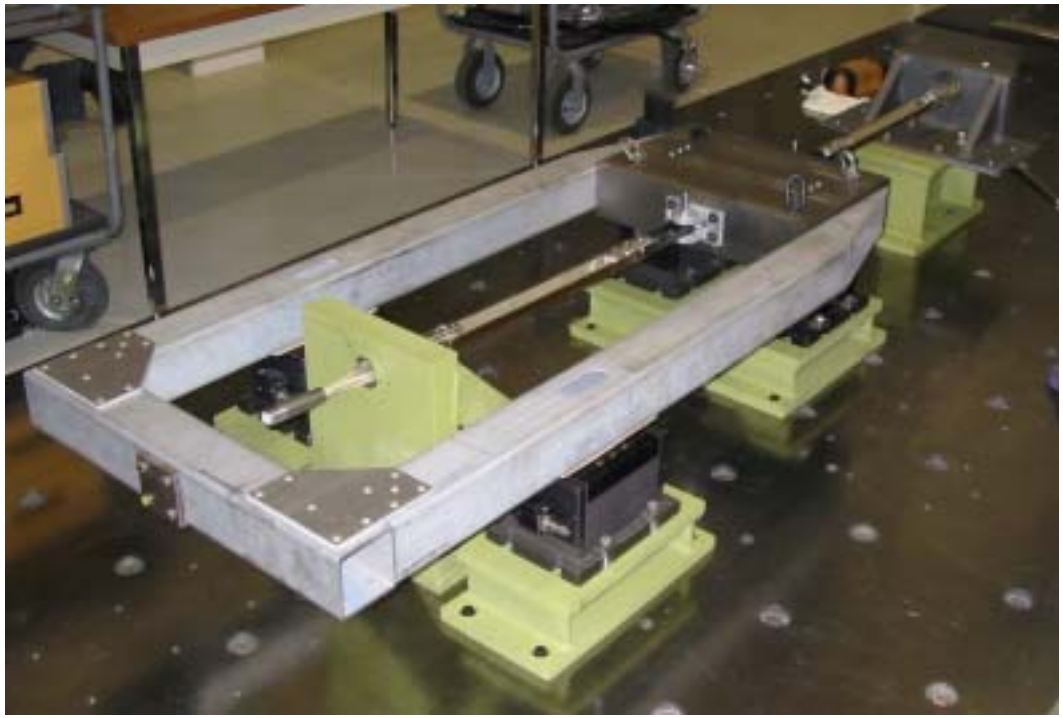
Acoustic Test Layout



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Frequency & Strength Verification Testing

- **Dynamic Tests**
  - **Cryomagnet Support System (Straps) (LM Denver)**
    - **2 complete strap assemblies were dynamically tested to determine dynamic and damping characteristics**
    - **Included enough instrumentation to dynamically correlate FEM of 1 DOF model**



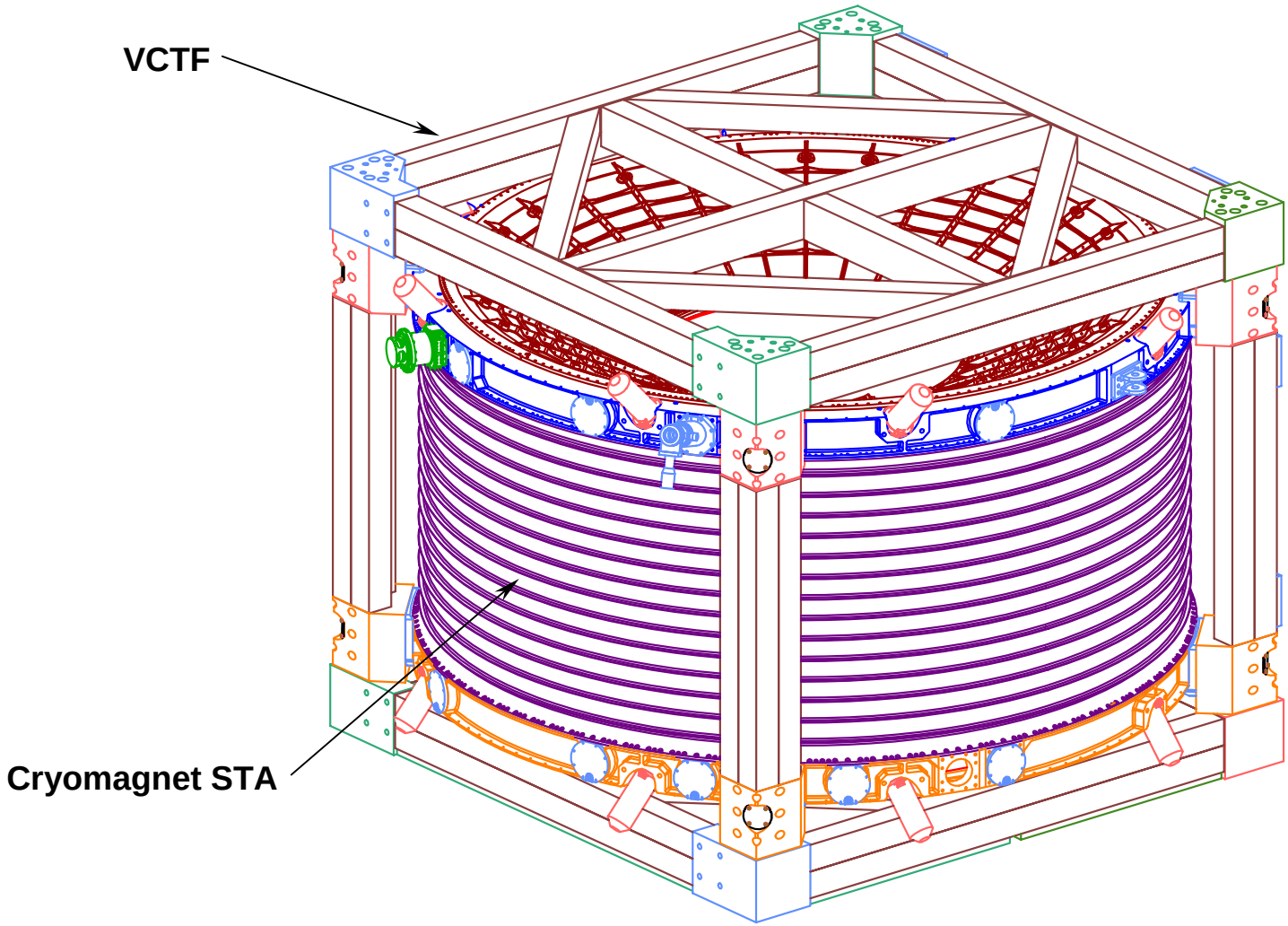
Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Frequency & Strength Verification Testing

- **Dynamic Tests (cont.)**
  - **Cryomagnet System Sine Sweep Tests (INFN)**
    - **Cryomagnet STA (STA VC, STA SFHe Tank, Cold Mass Replica) will be tested in a sine sweep test in order to excite the non-linear support straps to load levels so that the strap reaches and extends into the stiffness region associated with the launch strap engagement**
    - **Input environment will be developed using non-linear DCLA results. The Cryomagnet system response will be analytically determined and reproduced during testing.**
    - **Test will be performed with the system at cryogenic temperatures**
    - **Will include enough instrumentation to dynamically correlate FEM (Discussed during the Dynamics Presentation)**

Frequency & Strength Verification Testing

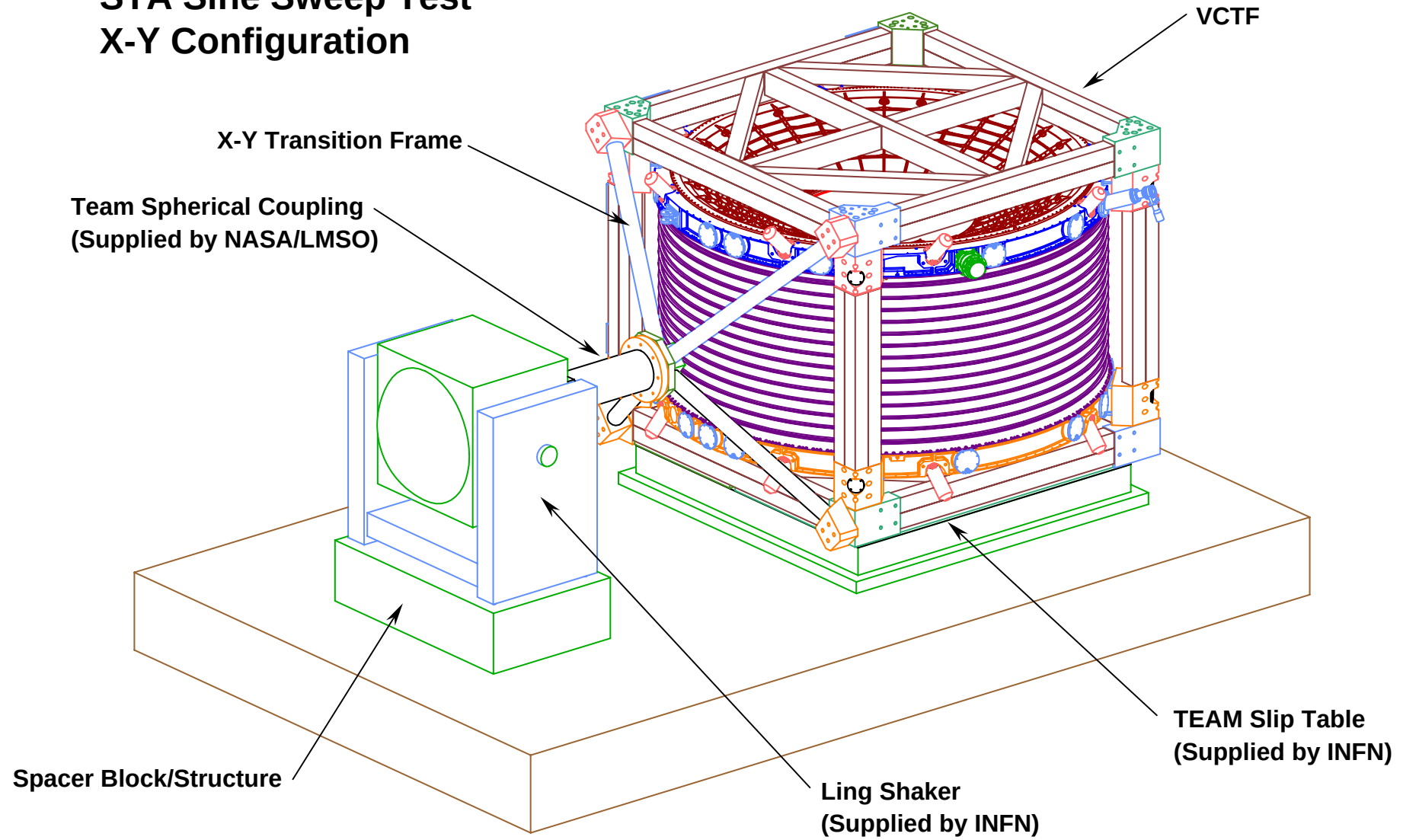
STA Cryosystem in the Vacuum Case Test Fixture (VCTF)



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Frequency & Strength Verification Testing

STA Sine Sweep Test
X-Y Configuration



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
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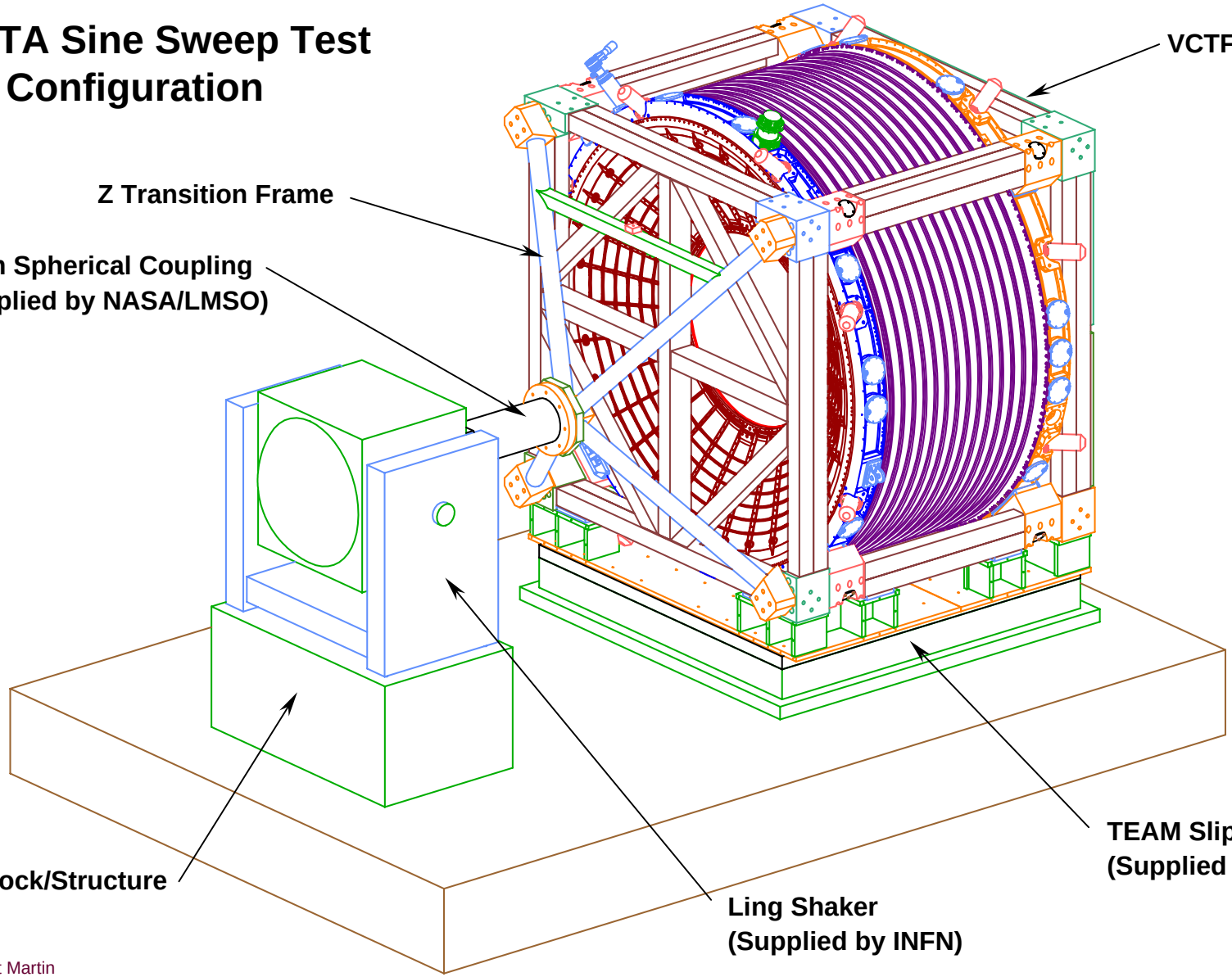
Frequency & Strength Verification Testing

STA Sine Sweep Test
Z Configuration



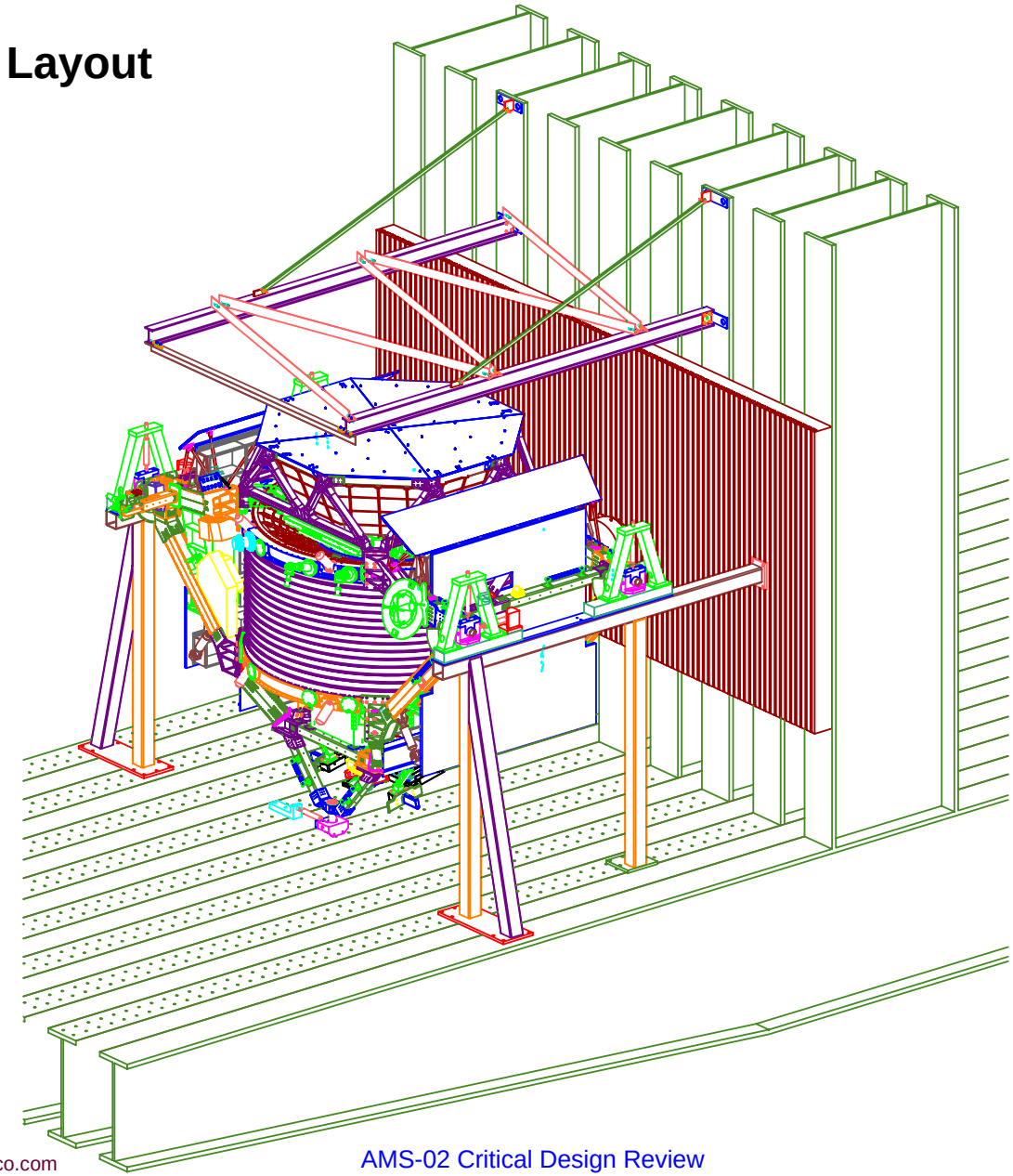
Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Frequency & Strength Verification Testing

- **Modal Tests**
  - **Full Assembly Modal Test (JSC STL – J13)**
    - **Orbiter Configuration simulated with modified test stands from AMS-01 on STS-91**
    - **Test will be performed with the system at cryogenic temperatures**
    - **Will include enough instrumentation to dynamically correlate FEM**

Frequency & Strength Verification Testing

Modal Test Layout



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Pressure System Verification Testing

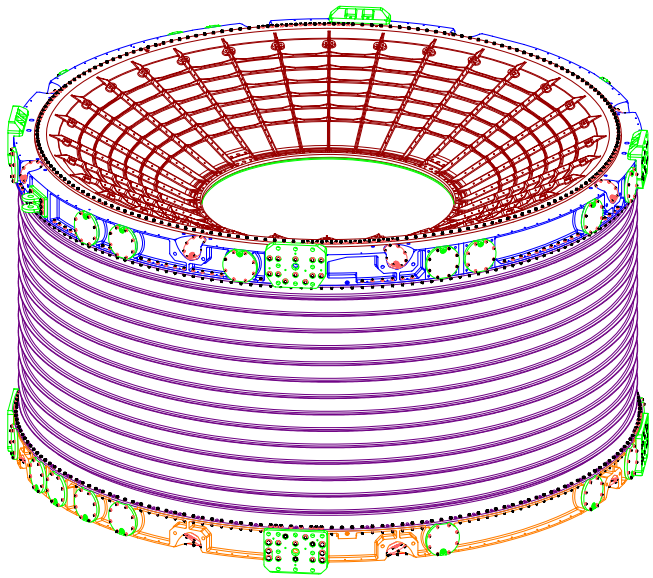
- O-Ring Test Fixture (JSC STL – Tests On-Going)
  - Sub-scale vacuum vessel will be used to show that the leak rate through the o-ring seals is at an acceptable level
  - Used to develop vacuum leak check procedures for the STA & Flight Vacuum Case
  - First vacuum pull was instrumented to aid in FEM correlation

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Pressure System Verification Testing

– Vacuum Case

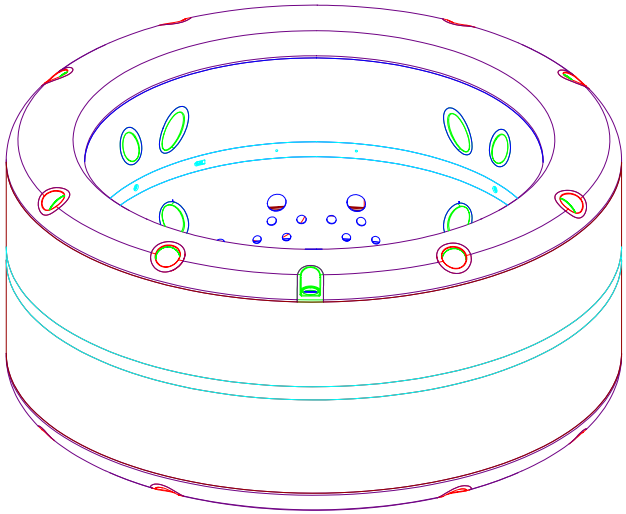
- Both the Flight & STA VC will undergo proof pressure testing to 1.0 x MDP (0.8 atm gauge). The STA will be proof tested twice. (This is an emergency case only because the system is designed for normal use as a vacuum vessel and not as a pressure vessel.)
- Both the Flight & STA VC will undergo vacuum leak checks at various stages during the static and dynamic testing.
- Vacuum leak checks at various stages of assembly and at final assembly.



Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Pressure System Verification Testing

- Cryomagnet Pressure Systems
  - SFHe Tank – Proof Pressure Tests to 1.1 x MDP
  - Plumbing Systems – Proof Pressure Tests to at least 1.5 x MDP
  - Warm He Tank – Proof Pressure Test to at least 1.5 x MDP
  - He Leak Tests – Throughout assembly and final assembly
  - Small Scale Dewar Vent Tests (Successfully Completed)
    - Safety Panel agrees that testing proved no Shuttle overboard vent will be required (See minutes “ams2tim011703”)



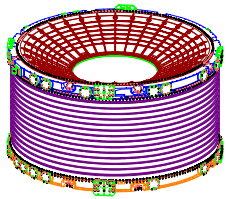
Pressure System Verification Testing

- TRD & TCS Pressure Systems
  - TRD Xe Tank
    - Proof Pressure Test to 1.5 x MDP
    - Random Vibration to 8.9 Grms - Exceeds AMS-02 requirements
    - Same as tank used in Plasma Contactor Unit (PCU) built by Arde
  - TRD CO_2 Tank
    - Proof Pressure Test to 1.5 x MDP
    - Random Vibration to 8.9 Grms (axial) & 4.5 Grms (lateral) - Exceeds AMS-02 requirements
    - Also built by Arde
  - TCS CO_2 Tank
    - Proof Pressure Test to 1.5 x MDP
  - Plumbing Systems
    - Proof Pressure Tests to at least 1.5 x MDP
  - Warm Helium Tank to Operate Cryosystem Warm Valves
    - Proof Pressure Test to at least 1.5 x MDP

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

Cyromagnet System Testing Flow

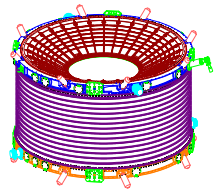
JSC / U.S.



STA VC

- Proof Pressure Test
- Vacuum Leak Check
- Perform Small Scale O-ring Leak Testing
- Perform Small Scale pressure testing
- Weld tests

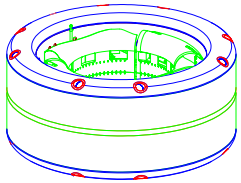
SCL, England



Cryomagnet STA

- Initial Assembly & Welding
- Proof Pressure Test
- Vacuum Leak Check

ETH, SCL, HBE



CMR
w/ STA SFHe Tank

- Proof Pressure Test
- He Leak Check

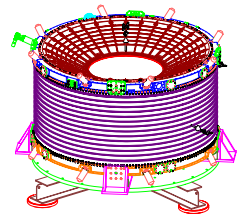
England/JSC/LM Denver

- Perform Strap Static/Dynamic/ Thermal/Fatigue Testing

England

- Small Dewar Vent Tests

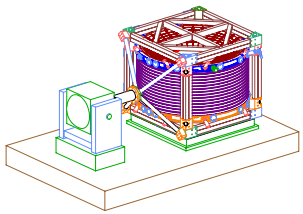
ESTEC, Netherlands



Cryomagnet STA

-Acoustic Test
-Vacuum Leak Test

INFN, Italy

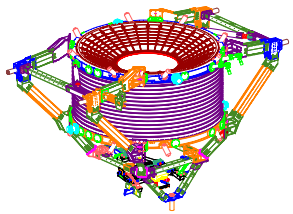


Cryomagnet STA

- Sine Sweep Test
- Vacuum Leak Checks during testing
- Begin Long Duration Vacuum Leak Tests

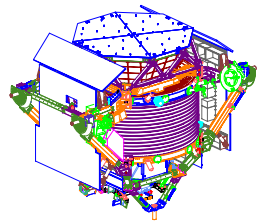
Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

JSC



- Install Cryomagnet STA into USS-02

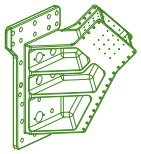
JSC



AMS-02

- Install Experiment Mass Sims and STA's onto USS-02

JSC



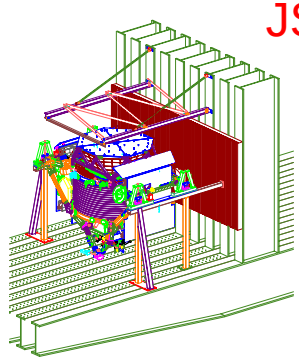
PAS Static Test

Components & MM&OD

NBL

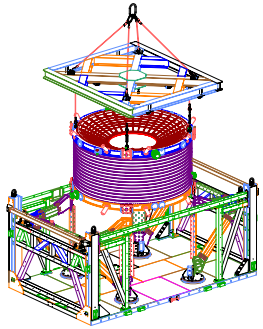
- Perform Tests of USS-02 Components
- Perform NBL Testing
- Perform MM&OD Testing

JSC



- Full Payload Modal Test
- Full Payload Static Test
- Vacuum Leak Checks during Tests

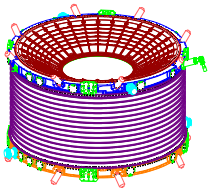
JSC



- Remove Cryomagnet STA
- Continue Long Duration Vacuum Leak Check of Cryomagnet STA
- Ship USS-02 to Switzerland

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

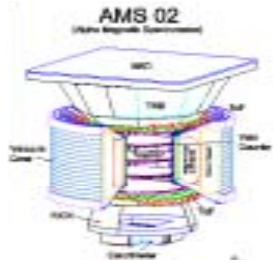
JSC



- Continue long duration endurance and leak checks

Cryomagnet STA

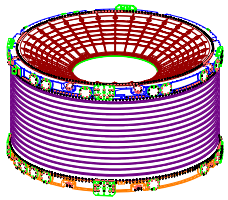
AMS Collaboration



-Experiment Components

-Sub-component Testing

JSC / U.S.

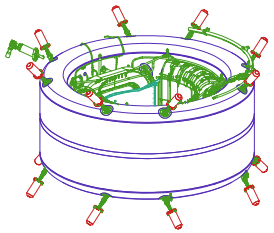


- Proof Pressure Test
- Vacuum Leak Check

Flight VC

Integrate Payload in Switzerland

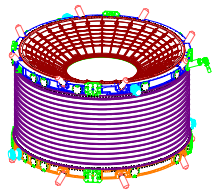
ETH / SCL / HBE



- He Tank Proof Pressure Test
- He Tank He Leak Check

Magnet

SCL, England

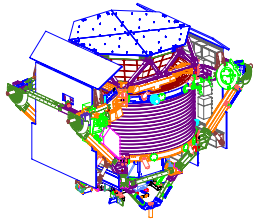


- Proof Pressure Test
- Vacuum Leak Check
- Magnetic Load Static Testing
- Quench Testing

Flight VC & Magnet

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com

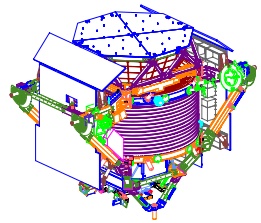
Switzerland / ESTEC



AMS-02

- Experiment Calibration
- Thermal Vacuum Test @ ESTEC

KSC

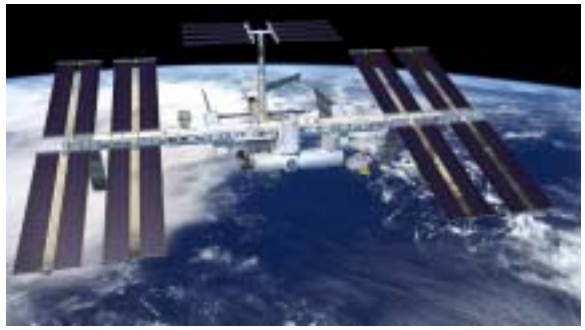


AMS-02

- KSC Processing

Launch

3 Operational Years



ISS

Landing

Phil Mott / Trent Martin
281-333-6451 / 281-335-2139
phil.mott@lmco.com / trent.martin@lmco.com